

# **AIR FORCE QUALIFICATION TRAINING PACKAGE (AFQTP)**



for  
**ENGINEERING**  
(3E5X1)

**MODULE 17**  
**CIVIL ENGINEERING DESIGN**

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CIVIL ENGINEERING DESIGN

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Career Field Education and Training Plan (CFETP) references from 1 Apr 97 version.

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**AIR FORCE QUALIFICATION TRAINING PACKAGES**  
**for**  
**ENGINEERING**  
**(3E5X1)**

**INTRODUCTION**

*Before starting this AFQTP*, refer to and read the “Trainee/Trainer Guide” located on the AFCESA Web site <http://www.afcesa.af.mil/>.

*AFQTPs are mandatory and must be completed* to fulfill task knowledge requirements on core and diamond tasks for upgrade training. *It is important for the trainer and trainee to understand* that an AFQTP **does not** replace hands-on training, nor will completion of an AFQTP meet the requirement for core task certification. AFQTPs will be used in conjunction with applicable technical references and hands-on training.

*AFQTPs and Certification and Testing (CerTest) must be used as minimum upgrade requirements for Diamond tasks.*

**MANDATORY minimum upgrade requirements:**

***Core task:***

AFQTP completion  
Hands-on certification

***Diamond task:***

AFQTP completion  
CerTest completion (80% minimum to pass)

***Note:*** *Trainees will receive hands-on certification training for Diamond Tasks when equipment becomes available either at home station or at a TDY location.*

***Put this package to use.*** Subject matter experts under the direction and guidance of HQ AFCESA/CEOT revised this AFQTP. If you have any recommendations for improving this document, please contact the Career Field Manager at the address below.

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## **CIVIL ENGINEERING DESIGN**

**MODULE 17**

**AFQTP UNIT 2 & 3**

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**PREPARE MATERIAL TAKE-OFFS (17.2.)**

**ESTIMATE COST ELEMENTS SUCH AS:  
MATERIALS, EQUIPMENT, AND LABOR (17.3.)**

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**PREPARE MATERIAL TAKE-OFFS****ESTIMATE COST ELEMENTS SUCH AS:  
MATERIALS, EQUIPMENT, AND LABOR*****Task Training Guide***

<b>STS Reference Number/Title:</b>	17.2. Prepare material take-offs 17.3. Estimate cost elements such as: materials, equipment, and labor
<b>Training References:</b>	<ul style="list-style-type: none"> <li>• R.S. Means 1999 Building Construction Cost Estimating Guide</li> <li>• Local Procedures</li> </ul>
<b>Prerequisites:</b>	<ul style="list-style-type: none"> <li>• Possess as a minimum a 3E531 AFSC</li> <li>• Must have completed volume 2, Design Considerations of the 3E551A Engineering Journeyman Career Development Courses</li> </ul>
<b>Equipment/Tools Required:</b>	<ul style="list-style-type: none"> <li>• Materials Take-offs Worksheet (Similar to Element's Sample)</li> <li>• AF Form 3052, Construction Cost Estimate Breakdown</li> </ul>
<b>Learning Objective:</b>	<ul style="list-style-type: none"> <li>• The trainee will be able to prepare material take-offs</li> <li>• The trainee will be able to estimate cost elements</li> <li>• The trainee will be able to use RS Means Estimating Guides</li> </ul>
<b>Samples of Behavior:</b>	<ul style="list-style-type: none"> <li>• The trainee will prepare material take-off and cost estimate</li> </ul>

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## PREPARE MATERIAL TAKE-OFFS

### ESTIMATE COST ELEMENTS SUCH AS: MATERIALS, EQUIPMENT, AND LABOR

**Background:** Cost estimating must be performed for every Air Force construction project. Estimating is an educated analysis of all resources required to complete a project. This is nothing more than good management practice which considers the 4 Ms; methods, manpower, material and machinery. Estimating begins by establishing a bill of materials also known as a BOM. A BOM, or a materials take off, is a listing and description of the various materials and the quantities required to complete a particular construction project. The estimator must compile this BOM by consulting various references to include engineers, users, and contract documents (e.g., plans and specifications). The important thing to remember is to ensure that the list is complete and accurate.

When preparing material takeoffs, keep these common sources of error in mind:

**Drawing notes and references** Failure to read all notes on a drawing or to examine reference drawings results in many omissions.

**Scaling drawings** Common scaling errors are using the wrong scale, reading the wrong side of a scale, and failing to note that a detail being scaled is drawn to a scale different from that of the rest of the drawing.

**Interpreting specifications** Wrong interpretation of a section of the specifications can cause errors in the estimate.

- **Omissions** Use checklists to ensure that all work elements or materials have been included in the estimate. If drawings are revised after takeoff, new issues must be compared with the copy used for takeoff and appropriate revisions made in the estimate.
- **Allowance for waste and loss** Failure to make proper allowance for waste and loss results in erroneous estimates. Also, there is the possibility of loss due to pilferage, vandalism, and weather damage.

**Prepare Material Take-offs** Estimators must mentally picture the separate operations involved during the construction process. They read drawings and obtain accurate measurements from them. They must have a working knowledge of construction disciplines, preferably knowledge based on previous construction experience. They must be able to evaluate the effects of numerous factors and conditions affecting construction and make allowances for these. Experienced estimators have a system for efficiently progressing from the receipt of plans and specifications to the final estimated project cost. Estimating involves totaling all individual costs and establishing total estimated costs of the project, including overhead and profit.

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*To develop an effective material take off, follow these steps:*

**Step 1: Study the plans and specifications**

- When estimators first receive the plans and specifications for a project, they should study them thoroughly to acquaint themselves with the project and learn exactly what the designer and the specifications writer have indicated or expressed. Dimensions shown on drawings or computed from those shown on drawings are used in preference to those obtained by scaling drawing distances. When there are inconsistencies between general drawings and details, details are followed unless they are obviously wrong. If there are inconsistencies between drawings and specifications, the specifications take precedence.

**Step 2: Visit the site**

- After becoming familiar with the proposed job, the estimators should visit the site of the project and consider the proposed location in relation to its surroundings. They should study the factors that affect the delivery cost of materials to the particular job, such as proximity to a freight siding and any difficulty that might be encountered in getting the materials from the freight siding to the site.
- The site is cleared before construction begins, excavated earth is disposed of after construction is underway, and the site is cleared again after construction is completed. These costs should be included in your take off.

**Step 3: Quantify, Prepare Material Take-offs**

- The material take-offs are a systematic listing of every essential detail shown on the plans and specifications, by quantity of materials required, in the usual unit of measure.
- A typical worksheet should have an item and reference number, description of item, computations, and total quantity of each material. (See figure 1).

**NOTE:**

When measuring work element quantities on a drawing, it is a good idea to begin at one side and work across to the opposite side, marking with a colored pencil each particular work element as it is measured and recorded. The colored marks show the estimator what has been taken off (thus preventing duplication) and provide a means of checking for omissions.

**NOTE:**

After the architectural and structural drawings, the mechanical and electrical drawings are worked. If applicable, these are followed by specialty or shop drawings. In each division, the order should be (1) plans, (2) elevations, and (3) details.

**NOTE:**

Begin by measuring work elements of the foundation and footing plan and proceed through the basement and each succeeding floor plan of the architectural and structural drawings. All references and detail drawings that refer to a particular plan are examined and worked in conjunction with that plan. After examination of the plans, the elevations and then the details are examined one by one, and all work not previously taken off is measured and recorded. Check your Unit of Measurement during computation twice.

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#	MEANS REF #	ITEM DESCRIPTION	COMPUTATION	TOTAL
1.	021 100 104-0010	Clear and Grub Light, trees to 6" diameter, cut & chip.	$8' \times 10' = 80' \times 100 \text{ units} = 8000 \text{ [SF / 43560 SF =]}$	0.2 acres
2.	033 100 130-4650	Ground Slab, not including finish, 4" thick including forms (four uses) and reinforcing steel.	$[(8' \times 10' \times .33') / 27 = .98 \text{ CY} \times 100 \text{ units} =]$	97.78 CY (round to 100 CY)
3.	033 450 454-0050	Finishing Floors Monolithic, Darby finish.	$[8' \times 10' \times 100 \text{ units} =]$	8000 SF
4.	031 100 110-0020	Accessories, Anchor Bolts, nut and washer included, 1/2" diameter, 6" long.	$[2 \text{ per side} = 8 \text{ per unit} =]$	800 bolts
5.	061 100 128-6165	Studs, 8' high wall, 2" x 6", pneumatic nailed.	$[24 \text{ studs per unit (18 for walls, 4 for corner nailers, 2 for door framing), } 24 \times 8' = 192 \text{ BF} \times 100 = 19200 \text{ BF} / 1000 =]$	19.2 MBF
6.	061 100 128-5865	Headers over openings, 2" x 6", pneumatic nailed.	$[1 \text{ header} = 6 \text{ BF} \times 100 = 600 \text{ BF} / 1000 =]$	0.6 MBF
7.	061 100 128-6040	Plates, untreated, 2" x 6", pneumatic nailed.	$[36' \times 2 \text{ (upper and lower plates)} = 72 \text{ BF} \times 100 = 7200 \text{ BF} / 1000 =]$	7.2 MBF
8.	074 600 611-2500	Plywood, Fir, rough sawn, natural finish, 3/8" thick.	$[(8' \times 8' \times 2) + (8' \times 10' \times 2) = 288 \text{ SF} \times 100 = 28800 \text{ SF} / 1000 =]$	28.8 MSF
9.	061 100 120-7880	Ridge Board, 2" x 6", No. 2 or better.	$[12' \times 100 = 1200 \text{ BF} / 1000 =]$	1.2 MBF
10.	062 200 220-3350	Fascia, 1" x 6", sterling pine.	$[24 \text{ LF per unit} \times 100 =]$	2400 LF
11.	062 700 775-1000	Soffits, exterior AC plywood, 1/4" thick.	$[24 \text{ SF per unit} \times 100 =]$	2400 SF
12.	061 150 154-0300	Sheathing, plywood on roof, CDX, 3/4" thick.	$[4 \text{ in } 12 \text{ pitch, } (1.67')^2 + (5')^2 = \sqrt{27.7889} = 5.27' \times 12 = 63.24 \times 2 = 126.48' \times 100 =]$	12648 SF
13.	061 100 120-7000	Rafters, 4 in 12 pitch, 2"x 6".	$[5.27 \times 2 = 10.54 \times 6 = 63.24 \text{ BF} \times 100 = 6324 \text{ BF} / 1000 =]$	6.33 MBF
14.	073 100 104-0150	Asphalt Shingles, Inorganic; class A, 210-235 lb./sq., 3 bundles/square.	$[126.48 \text{ SF per unit} \times 100 \text{ units} = 12648 \text{ SF} / 100 =]$	126.5 SQ
15.	073 100 104-0900	Ridge Shingles.	$[12' \times 100 =]$	1200 LF
16.	076 200 202-0010	Drip Edge, Aluminum, .016" thick, 5" wide, mill finish.	$[12' + 12' + 5.27' + 5.27' = 34.54 \text{ LF} \times 100 =]$	3454 LF
17.	081 100 114-1340	Residential Door, Steel, flush face, full panel, 3'-0" x 6'-8", 24 gauge.	$[100 \text{ doors}]$	100 each
18.	087 100 120-0400	Lockset, standard duty, cylindrical with sectional trim, keyed, single cylinder.	$[100 \text{ locksets}]$	100 each

Figure 1, Sample: Bill Of Materials (Material Take-offs)

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**Developing Cost Estimates** Construction cost estimates may be quite detailed, depending on the intended use of the estimates. If the estimates are to be used for planning and budgetary purposes, a preliminary estimate may suffice. If the estimates are supporting a request for project approval and funds, they are computed in detail. In preparing an estimate, estimators rely on their experience, their records, and published figures. These publications may be Air Force or commercial.

**Use of Means Cost Estimating Guide** The Means Cost Estimating Guide is Construction Management's primary reference for estimating changes. It provides valuable information on material, labor, and equipment costs associated with performing virtually all aspects of construction. Material costs are determined by consulting various product manufacturers, dealers, and distributors. The labor costs are determined by using the average wage rates from 30 major US cities. Equipment costs include rental and operating fees as required by contractors and equipment suppliers. The index, in the back of the book, provides a detailed, alphabetized listing of all elements of work. Let's walk through an *example* of pricing an item of construction. (Reference 1999 RSMeans Building Construction Cost Data Guide)

*To properly use 1999 RSMeans Building Construction Cost Data Guide, follow these steps. Reference the AF 3052 which follows step eight. The first line item is completed for you. Go through the step-by-step procedures for line item one and then complete each line item on the AF 3052. Notice the preceding BOM was used for the line items. After completion, your trainer will check and provide feedback.*

**Step 1: Prepare a cost estimate work sheet to compile your cost estimates data. Use your BOM as the line items needed. An AF 3052 is an excellent guide to use.**

**Step 2: Go to the index of the 1999 R.S.Means Building Construction Cost Data. There you should find the page number that corresponds to your subject or item.**

- Let's look up the first item under your BOM, clear and grub trees. The index tells you to look on pages 44.

**Step 3: Then determine which item meets the requirements for clear and grub trees, you want to estimate. Look at clear and grub cut & chip light, tress to 6" dia. page 44.**

**Step 4: Next, determine the type, size, and style needed. (The specifications will help with this information.)**

- In this instance, we don't need to look any further. We are already at the needed line item, item 021-104-0010. However, if our trees were 12" we would use line item 021-104-0200.

**Step 5: Looking across from this line item, you will be given the unit of measure (Acre.), Material cost (\$0), Labor cost (\$1100) and Equipment cost (\$1175). Also note the column for O&P (overhead and profit). We will discuss this column later.**

- There is no material cost listed for the removal of trees because there are no new materials needed. However, we must note that in our BOM we only need to work on .2 acres. Therefore, our line item cost for material is (\$0), unit x material cost or .2 x \$0; labor cost is (\$220) .2 x 1100; equipment cost is (\$235) or .2 x \$1175. Our total line item cost for this line item is \$455.00 (\$220.00+\$235.00)

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**Step 6: Repeat the above process of finding the material, labor, and equipment costs for each item on your materials takeoff sheet in the means catalog.**

- Remember that you must multiply the costs of each unit by the quantity.

**Step 7: Once you have completed the pricing of each entry on your materials takeoff sheet, you will need to total the project cost.**

**Step 8: Now that you have a project cost, you will need to factor in the costs of the contractors overhead and profit to come up with the total project estimated cost.**

- **Overhead** is all of the general expenses of operating a construction business. Generally, for estimating purposes, overhead is 15% of the estimated project cost. Multiply your project cost times 15% and add this cost to come up with a project cost plus overhead.
- **Profit** is self-explanatory. Generally, for estimating purposes, profit is 10% of the project cost plus overhead. Multiply project cost plus overhead times 10% and add this cost to come up with the overall project cost. Note that RS Means has a column that includes overhead and profit. For our purposes, we are not concerned with this column. Contact your trainer for local guidance using this column.

**Note:**

Because of the need for accuracy, you should check estimates in a manner that eliminates as many errors as possible. Having another person make an independent estimate and comparing the two is an excellent way to verify the accuracy of your estimate and eliminate errors.

CONSTRUCTION COST ESTIMATE BREAKDOWN										
CONTRACTOR					ADDRESS					
CONTRACT FOR (Work to be performed)					PROPOSED TOTAL CONTRACT PRICE					
PURCHASE REQUEST NUMBER			PROJECT NUMBER			WORK LOCATION				
LINE NO.	ITEM (1)	UNIT OF MEASURE (2)	QUANTITY (3)	MATERIAL COST		LABOR COSTS			OTHER DIRECT COSTS (9)	LINE TOTAL (10)
				UNIT (4)	TOTAL (5)	MANHOURS MANDAYS (6)	AVERAGE RATE (7)	TOTAL (8)		
1	CLR & GRB	ACRES	0.2				1100.00	220.00	235.00	455.00
2	SLAB	CY	100							
3	FINISHING	SF	8000							
4	ANCR BOLT	EA	800							
5	STUDS	MBF	19.2							
6	HEADERS	MBF	0.6							
7	PLATES	MBF	7.2							
8	SIDING, PLY	SF	28,800							
9	RIDGE	MBF	1.2							
10	FASCIA	LF	2400							
11	SOFFITS	SF	2400							
12	SHEATHING	SF	12,648							
13	RAFTERS	MBF	6.324							
	SUBTOTAL1									

AF FORM 3052, JAN 88

CONSTRUCTION COST ESTIMATE BREAKDOWN										
CONTRACTOR					ADDRESS					
CONTRACT FOR (Work to be performed)					PROPOSED TOTAL CONTRACT PRICE					
PURCHASE REQUEST NUMBER			PROJECT NUMBER			WORK LOCATION				
LINE NO.	ITEM (1)	UNIT OF MEASURE (2)	QUANTITY (3)	MATERIAL COST		LABOR COSTS			OTHER DIRECT COSTS (9)	LINE TOTAL (10)
				UNIT (4)	TOTAL (5)	MANHOURS MANDAYS (6)	AVERAGE RATE (7)	TOTAL (8)		
14	SHINGLES	SQ	126.48							
15	RIDGE SHIN	LF	1,200							
16	DRIP EDGE	LF	3,454							
17	DOOR	EA	100							
18	LOCKSET	EA	100							
	SUBTOTAL2									
	SUB 1 & 2									
	15% OVH									
	SUB + OVH									
	10% PROFIT									
	TOTAL									

AF FORM 3052, JAN 88

Figure 2, Sample: Cost Estimating Worksheet

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**Review Questions  
for  
Prepare Material Take Offs  
Estimate Cost Elements such as:  
Materials, Equipment, and Labor**

<b>Question</b>	<b>Answer</b>
1. List five places where estimating errors may occur.	Written answer
2. How can estimators fully acquaint themselves with a project?	Written answer
3. When measuring work element quantities, what is the order that the drawings should be worked?	Written answer
4. Where is the information obtained for preparing material take-offs or bill of materials?	Written answer
5. Which of the following is one of the best ways to check an estimate?	a. Have another person make an independent estimate and compare the two b. Add all the figures backwards c. Read through the estimate back to front d. Wait until the contractor submits an estimate and compare the two

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## PREPARE MATERIAL TAKE-OFFS

### ESTIMATE COST ELEMENTS SUCH AS: MATERIALS, EQUIPMENT, AND LABOR

Performance Checklist		
Step	Yes	No
1. Was a thorough review of the plans and specifications completed?		
2. Was a site visit made?		
3. Was a systematic approach used to develop the materials takeoff?		
4. Is the materials takeoff a complete product reflecting all the materials and quantities required to complete the cost estimate?		
5. Did the trainee properly use the means catalog to gather cost data?		
6. Were item costs properly calculated taking into consideration quantities?		
7. Were overhead and profit costs properly added to calculate a total project cost?		

**FEEDBACK:** Trainer should provide both positive and/or negative feedback to the trainee immediately after the task is performed. This will ensure the issue is still fresh in the minds of both the trainee and trainer.

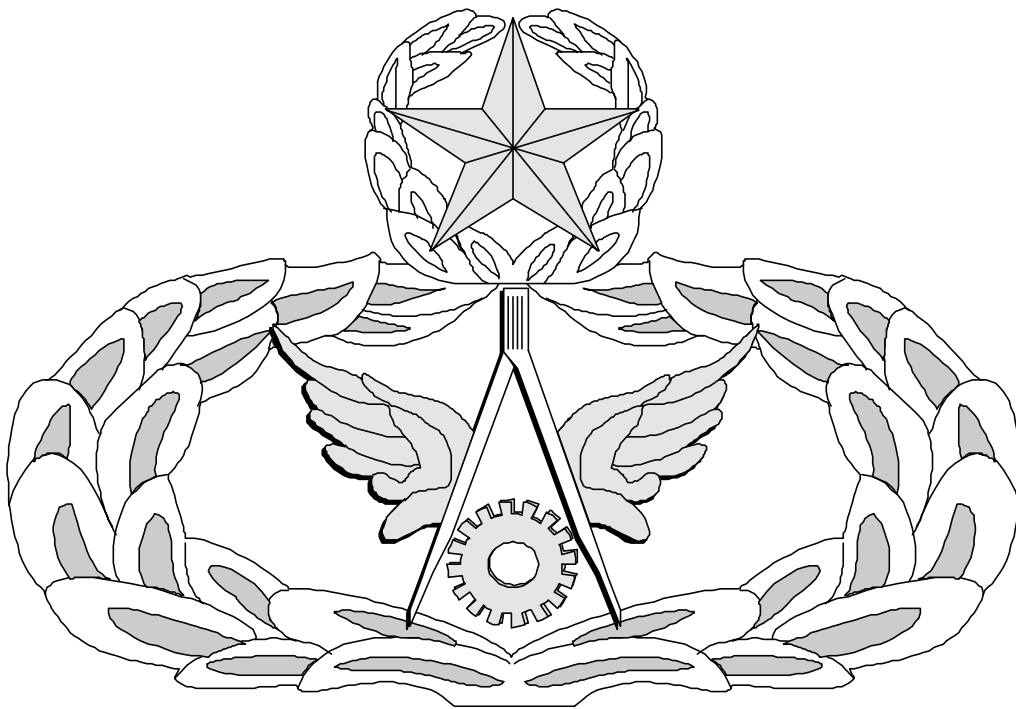
**Note:** The performance checklist above is not restricted to the given, trainer is highly encouraged to make additions/revisions in order to facilitate this QTP and maximize the training objective. New performance checklist must conform within the guidelines of this specific element.

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# Air Force Civil Engineer

## QUALIFICATION TRAINING PACKAGE (QTP)

### REVIEW ANSWER KEY



For  
ENGINEERING

(3E5X1)

MODULE 17

CIVIL ENGINEERING DESIGN

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Key-1

CONSTRUCTION COST ESTIMATE BREAKDOWN										
CONTRACTOR					ADDRESS					
CONTRACT FOR (Work to be performed)								PROPOSED TOTAL CONTRACT PRICE		
PURCHASE REQUEST NUMBER			PROJECT NUMBER				WORK LOCATION			
LINE NO.	ITEM (1)	UNIT OF MEASURE (2)	QUANTITY (3)	MATERIAL COST		LABOR COSTS			OTHER DIRECT COSTS (9)	LINE TOTAL (10)
				UNIT (4)	TOTAL (5)	MANHOURS MANDAYS (6)	AVERAGE RATE (7)	TOTAL (8)		
1	CLR & GRB	ACRES	0.2				1100.00	220.00	235.00	455.00
2	SLAB	CY	100	73.50	7350.00		39.00	3900.00	62.00	11312.00
3	FINISHING	SF	8000				0.28	2240.00		2240.00
4	ANCR BOLT	EA	800	1.11	888.00		2.43	1944.00		2832.00
5	STUDS	MBF	19.2	540.00	10368.00		365.00	7008.00		17376.00
6	HEADERS	MBF	0.6	540.00	324.00		1125.00	675.00		999.00
7	PLATES	MBF	7.2	525.00	3780.00		1025.00	7380.00		11160.00
8	SIDING, PLY	SF	28,800	0.61	17568.00		0.65	18720.00		36288.00
9	RIDGE	MBF	1.2	540.00	648.00		875.00	1050.00		1698.00
10	FASCIA	LF	2400	0.70	1680.00		0.87	2088.00		3768.00
11	SOFFITS	SF	2400	0.50	1200.00		1.04	2496.00		3696.00
12	SHEATHING	SF	12,648	0.58	7335.84		0.36	4553.28		11889.12
13	RAFTERS	MBF	6.324	540.00	3414.96		435.00	2750.94		6165.90
	SUBTOTAL1				54556.80			55025.22	297.00	109879.02

**AF FORM 3052, JAN 88**

CONSTRUCTION COST ESTIMATE BREAKDOWN										
CONTRACTOR					ADDRESS					
CONTRACT FOR (Work to be performed)								PROPOSED TOTAL CONTRACT PRICE		
PURCHASE REQUEST NUMBER			PROJECT NUMBER				WORK LOCATION			
LINE NO.	ITEM (1)	UNIT OF MEASURE (2)	QUANTITY (3)	MATERIAL COST		LABOR COSTS			OTHER DIRECT COSTS (9)	LINE TOTAL (10)
				UNIT (4)	TOTAL (5)	MANHOURS MANDAYS (6)	AVERAGE RATE (7)	TOTAL (8)		
14	SHINGLES	SQ	126.48	26.00	3288.48		35.00	4426.80		7715.28
15	RIDGE SHIN	LF	1,200	0.72	864.00		0.58	696.00		1560.00
16	DRIP EDGE	LF	3,454	0.20	690.80		0.55	1899.70		2590.50
17	DOOR	EA	100	193.00	19300.00		29.00	2900.00		22200.00
18	LOCKSET	EA	100	64.50	6450.00		22.00	2200.00		8650.00
	SUBTOTAL2				30593.28			12122.50	0.00	42715.78
	SUB 1& 2				85150.08			67147.72	297.00	152594.80
	15% OVH									22889.22
	SUB + OVH									175484.02
	10% PROFIT									17548.40
	TOTAL									183761.12

**AF FORM 3052, JAN 88**

Figure 2, Sample: Cost Estimating Worksheet (filled out)

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**PREPARE MATERIAL TAKE-OFFS  
(3E5X1-17.2.)**

**ESTIMATE COST ELEMENTS SUCH AS:  
MATERIALS, EQUIPMENT, AND LABOR  
(3E5X1-17.3.)**

Question	Answer
1. List five places where estimating errors may occur.	Drawing notes and references, scaling drawings, interpreting specifications, omissions, and allowances for waste
2. How can estimators acquaint themselves fully with a project?	By thoroughly studying the plans and specifications.
3. When measuring work element quantities, what is the order that the drawings should be worked?	A good idea is to begin at one side and work to the opposite side.
4. Where is the information obtained for preparing material take-offs or bill of materials?	Construction drawings and specifications are the main basis for preparing material take-offs.
5. Which of the following is one of the best ways to check an estimate?	a. Have another person make an independent estimate and compare the two.

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